

ENGINEERING DESIGN FILE

EDF No.: 4208

EDF Rev. No.: 0

Project File No.: 23048

1. Title: ANL-W Radioactive Inserts Stored at ILTSF				
2. Index Codes: Building/Type _____ SSC ID _____ Site Area <u>RWMC</u>				
3. NPH Performance Category: _____ or <input checked="" type="checkbox"/> N/A				
4. EDF Safety Category: _____ or <input checked="" type="checkbox"/> N/A SCC Safety Category: _____ or <input checked="" type="checkbox"/> N/A				
5. Summary: To prepare for retrieval and shipment to ANL-W, the storage locations at the ILTSF of 30 inserts containing radioactive waste from ANL-W are identified. This EDF also gives a brief description of the container configuration, container weights, and radionuclide contents as of December 31, 2003 based on historical data. To aid planning for handling the inserts, contact dose rates as of December 31, 2003 are calculated from a correlation developed from available data on Co-60/Cs-137 contents and measured dose rates at time of initial shipment of these inserts to the RWMC.				
6. Review (R) and Approval (A) and Acceptance (Ac) Signatures: (See instructions for definitions of terms and significance of signatures.)				
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Independent Peer Reviewer (if applicable)	R	George A. Beitel/4632 Systems Engineering	<i>George A. Beitel</i>	11/10/03
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8. Does document contain sensitive unclassified information? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If Yes, what category:				
9. Can document be externally distributed? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No				
10. Uniform File Code: <u>6150</u> Disposition Authority: <u>ENV1-J-1</u> Record Retention Period: <u>Cut off when superseded, obsolete or cancelled; see LST-9</u>				
11. For QA Records Classification Only: <input type="checkbox"/> Lifetime <input checked="" type="checkbox"/> Nonpermanent <input type="checkbox"/> Permanent Item and activity to which the QA Record apply:				
12. NRC related? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No				

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2. Index Codes: Building/Type _____ SSC ID _____ Site Area <u>RWMC</u>
13. Registered Professional Engineer's Stamp (if required)

ANL-W Radioactive Waste Inserts Stored at ILTSF

1. Introduction

Between 1978 and 1988, Argonne National Laboratory -West (ANL-W) shipped 28 containers of laboratory radioactive waste, referred to as *inserts*, to the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL). The waste in these containers was generated from destructive examination of fuel elements irradiated in the Experimental Breeder Reactor-II (EBR-II) reactor. The waste consisted of laboratory equipment and disposable material contaminated with radioactive material during the destructive examination, but did not include the fuel elements themselves. In 1988, ANL-W also shipped two inserts containing waste from the Bettis Atomic Power Laboratory to the RWMC. These two inserts contained waste generated from the examination of the experimental light water breeder reactor fuel. Their radioisotope contents included Th-232, U-233, and other radioisotopes in the thorium cycle. Almost all the inserts had contact dose rates at the time of shipment of over 50 rem/hr and a couple of them had contact dose rates exceeding 1000 rem/hr. These inserts are now stored in underground vaults at the Intermediate-Level Transuranic Storage Facility (ILTSF).

The ANL-W inserts contained wastes with content codes 150 (laboratory waste), 152 (plutonium neutron source), and 153 (laboratory waste - combustible) from the Hot Fuel Examination Facility (HFEF) at ANL-W. (For content code descriptions, see Reference 1.) The HFEF consists of two buildings, HFEF-South (building ANL-765) and HFEF-North (building ANL-785). The HFEF is a heavily shielded, negative pressure facility, capable of handling highly radioactive transuranic materials.

The ANL-W inserts have high surface dose rates that are quite distinct from most other waste containers stored at the ILTSF. For example, the 30-gal waste drums from ANL-East (ANL-E) generally have contact dose rates less than 10 rem/hr, while many of the ANL-W inserts have contact dose rates exceeding 100 rem/hr, making the ANL-W inserts less acceptable to disposal at the Waste Isolation Pilot Plant (WIPP) without treatment or repackaging based on dose rate alone. (No more than 5 volume percent of the transuranic waste received at WIPP may have surface dose rates exceeding 100 rem/hr and no waste whose surface dose rate exceeds 1000 rem/hr is acceptable at WIPP.) The waste may also contain prohibited items not acceptable at WIPP. In addition, without repackaging, the inserts, which measure more than 6 ft in height and approximately 1 ft in diameter, may be cumbersome to transport to WIPP. For these reasons, the best strategy to dispose of these inserts seems to be shipping these inserts back to the HFEF where they can be treated and/or repackaged so that they will be acceptable for disposal at WIPP.

The purpose of this Engineering Design File (EDF) is to document the storage configuration of the inserts and their expected dose rates in support of their anticipated retrievals from the ILTSF and shipment to the ANL-W.

2. Insert Configuration

An ANL-W insert consists of two concentric cylindrical cans. The inner can contains the waste and is placed inside the outer can. The dimensions of the cans are shown in Figure 1. Note that the cans are approximately 1 ft in diameter and approximately 6 ft long. An insert generally weighs slightly more than 200 kg (approximately 450 lb.)

The inserts from HFEF-South (ANL-765) and HFEF-North (ANL-785) are similar except in the method of sealing the outer can: a lid with O-ring seal is latched to the outer can for the HFEF-South inserts and a lid is continuously welded to the outer can for the HFEF-North inserts. Both types of inserts have flexible steel cables attached to the lids to permit easy lifting.

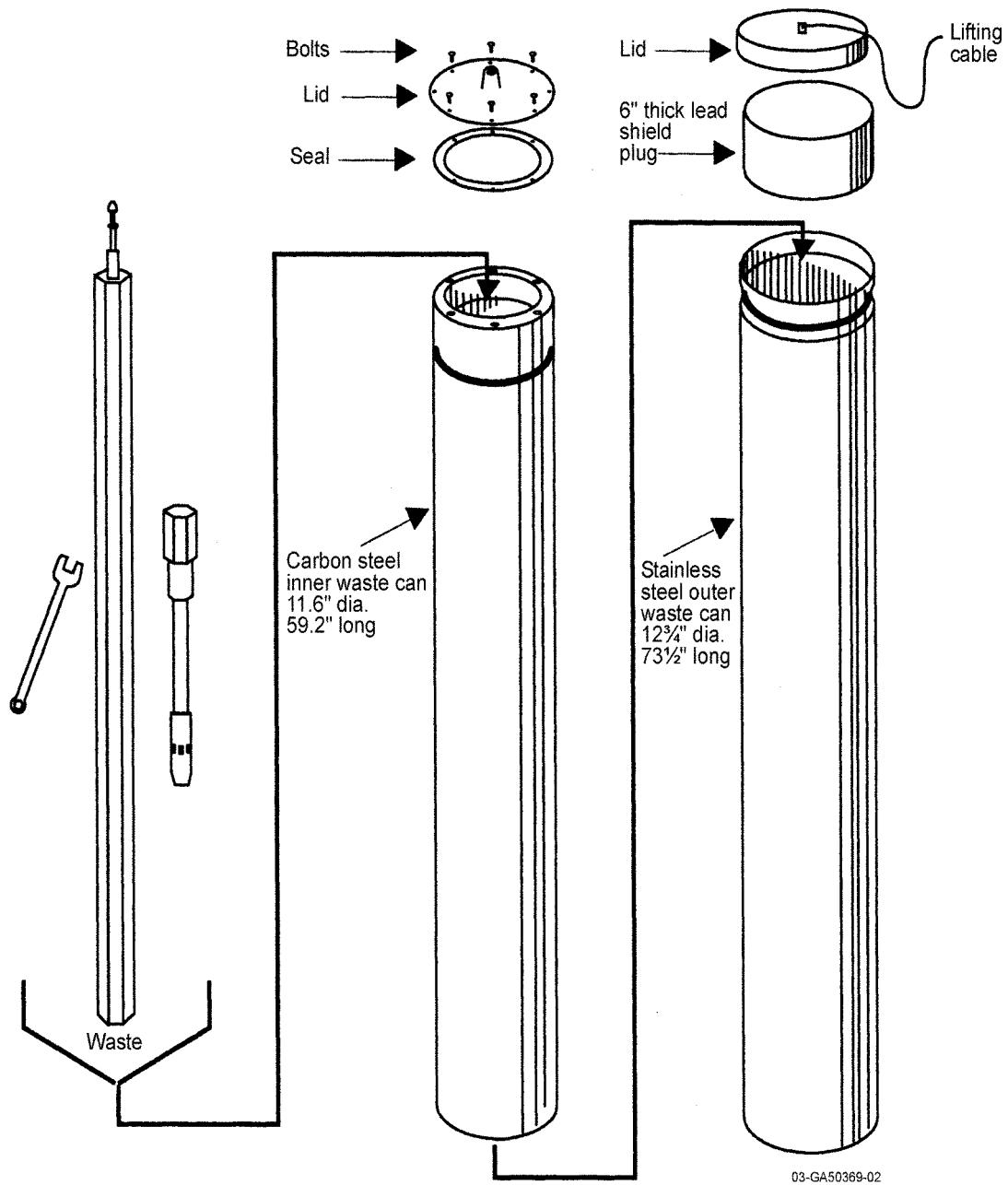


Figure 1. Schematic of ANL-W waste container (ANL-W insert).

3. Locations of Inserts in ILTSF vaults

The inserts were placed in 16-in. diameter vaults at the ILTSF. These vaults are approximately 17 ft deep with a 4-ft concrete plug at the top so that each vault can store two 6-ft inserts. The location of a vault is identified by a lettered column (A through F) and a numbered row (1 through 58). The layout of the vaults in the ILTSF pad is shown in Figure 2. The storage position of an insert in a vault is labeled 1 or 2, 1 referring to the bottom position and 2 the top position; for example, the storage position C-5-2 refers to the top position of the vault in column C and row 5.

Table 1 shows the storage locations of the inserts. Information on the storage locations was compiled from RWMIS RH-TRU Records (Historical Disposed Shipment Detail Listing, Reference 2) and ILTSF storage logs (Reference 3). The container identification and last package dates for years up to 1984 are obtained from a transmittal from Stan Stantliff of ANL-W to D. E. Kudera of EG&G, Idaho. (Reference 4) Any suspected typographical errors have been corrected and noted. For future reference to container information in the planned Integrated Waste Tracking System (IWTS) at the INEEL, TRIPS (Reference 5) container identification numbers are also included in the table. It is anticipated that the TRIPS data will be loaded into the IWTS.

ENGINEERING DESIGN FILE

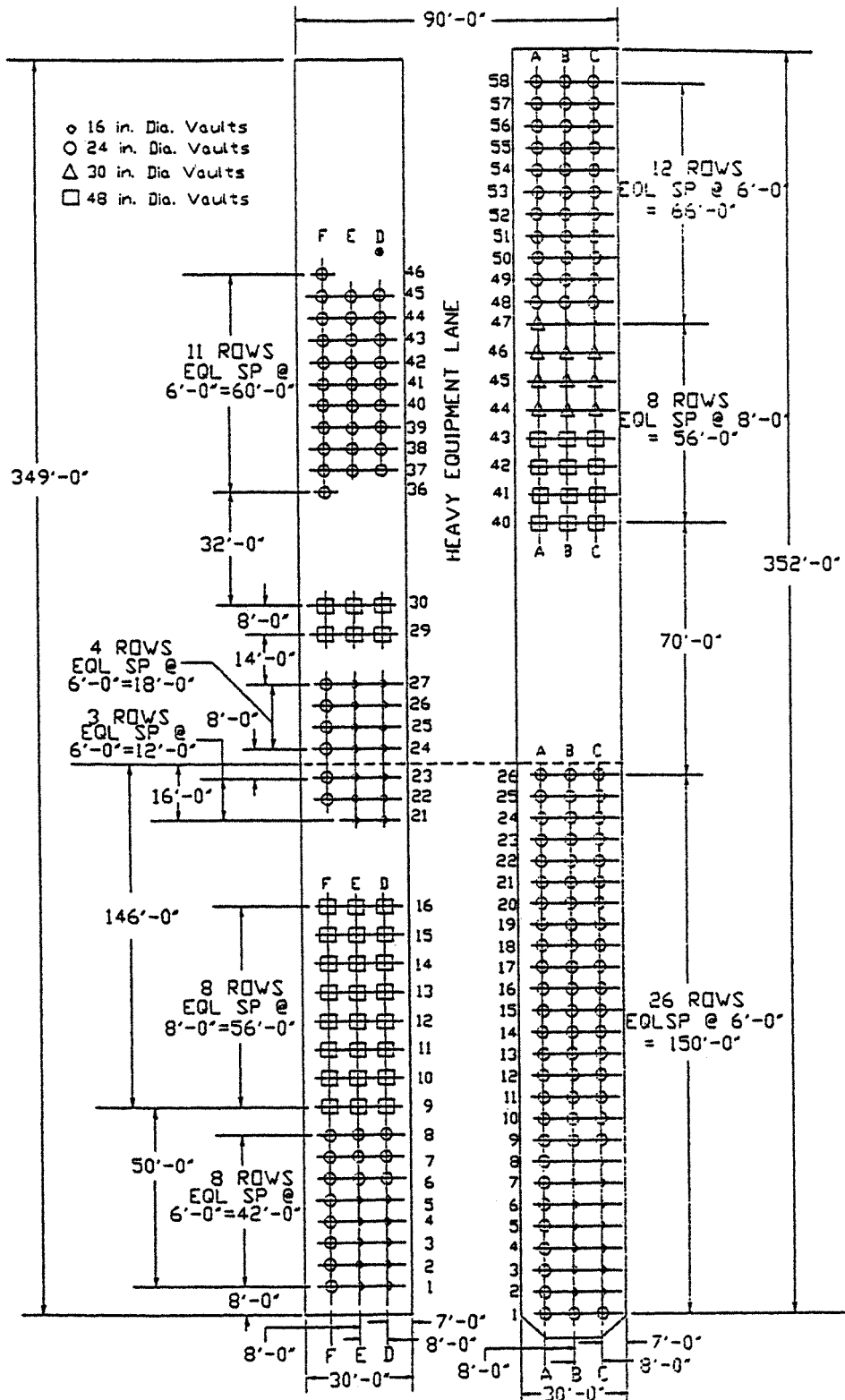


Figure 2. Vault layout at the ILTSF pad.

Table 1. Storage information for ANL-W inserts.

Shipment No.	Container No.	TRIPS container ID No.	Origin	Date ^a	Vault location	Mass (kg)
78-204	B-254	IDAW78-204	ANL765	8/16/78	C-7-1	203
79-57	B-262	N/A ^b	ANL765	3/5/79	C-6-1	213
79-74	B-266	IDAW79-74	ANL765	3/8/79	C-5-1 ^c	208
79-203	N-52	IDAW79-203	ANL785	12/18/79	C-7-2	204
80-52	N-55	IDAW80-52	ANL785	2/28/80	C-8-1 ^d	220
80-81	B-288	IDAW80-81	ANL765	5/6/80	C-2-1	199
80-145	B-287	IDAW80-145	ANL765	8/15/80	C-8-2	204
80-158	N-68	IDAW80-158	ANL785	9/11/80	C-5-2	222
81-2	B-293	IDAW81-2	ANL765	12/19/80	B-2-1 ^e	201
81-81	N-77	IDAW81-81	ANL785	4/20/81	B-2-2	228
81-91	N-79	IDAW81-91	ANL785	5/18/81	C-2-2	216
81-122	B-296	IDAW81-122	ANL765	7/2/81	B-3-1	207
81-177	N-85	IDAW81-177	ANL785	11/30/81	C-6-2	214
82-38	B-203	IDAW82-38	ANL765	4/6/82	B-3-2	203
82-66	N-94	IDAW82-66	ANL785	6/18/82	C-4-1	213
82-118	N-96	IDAW82-118	ANL785	7/7/82	C-4-2	209
83-4	N-105	IDAW83-4	ANL785	1/7/83	C-3-1	214
83-20	N-104	IDAW83-20	ANL785	2/7/83	C-3-2	209
83-133	N-111	IDAW83-133	ANL785	8/23/83	B-4-1	227
84-008	O-31	IDAW84-008	ANL785	12/13/83	B-5-1	219
85-013	85-013	IDAW85-013	ANL765	2/21/85	D-1-1	210
87-023	87-098	IDAWANL-87098	ANL785	4/3/87	B-6-1	214
87-029	87-105	IDAWANL-87105	ANL765	4/21/87	B-7-1 ^f	219
87-038	87-107	IDAWANL-87107	ANL765	6/10/87	B-8-1 ^g	216
87-049	87-114	IDAWANL-87114	ANL785	8/7/87	E-1-1 ^h	219
87-070	87-203	N/A ^b	ANL785	11/20/87	D-2 ⁱ	241
88-016	88-090	IDAWANL-88090	ANL765	3/8/88	B-6-2	214
88-031	88-130	IDAWANL-88130	ANL785	4/21/88	E-2-2	232
88-025	88-107	N/A ^b	Bettis	4/14/88	E-2-1	230 ^j
88-045	88-164	N/A ^b	Bettis	5/31/88	E-3-1	230

^a Before 1985, dates refer to last package dates; after 1985, dates refer to receipt dates.

^b Not available.

^c RWMIS shows C-S-1.

^d RWMIS shows C-8.

^e Listed as located at TSA-ASB2 in RWMIS.

^f RWMIS shows B-7.

^g RWMIS shows B-7.

^h RWMIS shows E-1.

ⁱ Location uncertain - RWMIS listed as D-2 but no record from ILTSF log.

^j RWMIS shows 330 kg.

4. Radioisotope Contents in Inserts

The radioisotope contents in the inserts are extracted from the RWMIS database. (Reference 2) For years up to 1984, these are compared with the radioisotope contents in the waste can log cards transmitted by Stantliff to Kudera. (Reference 4) At the time of loading of the cans, the operators filled out the loaded material and its weight into the can log cards, while the responsible engineer filled out total weights and activities on the front cover of the log cards. When discrepancies exist between the RWMIS database and the information on the log cards, information on the log cards prevails because it is considered primary information. In addition, some listed Pu-240 contents in the RWMIS are found to be a factor of 10 too low based on normal Pu-240 to Pu-239 ratios of a few percent. The activities of Pu-240 in these inserts are changed upwards by a factor of 10 to conform to normal Pu-240 to Pu-239 ratios. The radioisotope contents are then decay-corrected to December 31, 2003 from the last package date or the shipment date when the last package date is not available. The radioisotope contents in the inserts are listed in Table 2. Note that the listing of radionuclides present is not entirely consistent regarding certain nuclides. For example, in some inserts where Sr-90 should be present when Cs-137 is, Sr-90 is not listed in the database. In most other inserts where Sr-90 is listed, the Sr-90 activity is listed as the same as that of Cs-137 at the time of shipment. (The slight difference between the Sr-90 and Cs-137 activity at December 31, 2003 is due to the slight difference in decay half-lives of these isotopes.) Also, except for the two inserts that contained waste from Bettis, the short-lived decay daughters of Cs-137 and Sr-90 are not listed in the database, while in fact, these decay daughters (Ba-137M and Y-90) should have the same activities as their parents, respectively.

Table 2. Radioisotope contents (generator supplied data) of inserts as of December 31, 2003.

Shipment No. 78-204

Container No. B-254

Vault location: C-7-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	3.542E-09	4.578E-13
fission product	Cs137	1.113E+00	1.279E-02
fission product	Ce144	1.532E-10	4.802E-14
actinide	Pu239	3.677E-02	5.916E-01
actinide	Pu240	7.151E-03 ^a	3.138E-02 ^b
	MFP ^c	1.000E+00	---
Total		2.150E+00	6.075E-01

Shipment No. 79-57

Container No. B-262

Vault location: C-6-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	5.532E-09	7.150E-13
activation product	Fe 59	1.000E+00	2.033E-05
activation product	Co 60	3.819E-02	3.378E-05
actinide	U235	2.270E-04	1.050E+02
actinide	U238	2.030E-05	6.038E+01
actinide	Pu239	3.008E-02	4.839E-01
actinide	Pu240	5.845E-03 ^d	2.565E-02
Total		1.069E+00	1.659E+02

Shipment No. 79-74

Container No. B-266

Vault location: C-5-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	3.713E-09	4.799E-13
fission product	Cs134	2.383E-04	1.841E-07
fission product	Cs137	1.127E+00	1.296E-02
fission product	Ce144	2.519E-10	7.897E-14
actinide	Np237	2.700E-08	3.830E-05
actinide	Pu239	5.666E-01	9.115E+00
actinide	Pu240	2.025E-01	8.886E-01
	MAP ^e	1.000E+00	---
	MFP ^c	1.000E+00	---
Total		3.896E+00	1.002E+01

^a Based on ANL-W can log; RWMIS value is a factor of 10 lower.

^b Based on normal Pu-240 to Pu-239 ratio and corrected Pu-239 value.

^c mixed fission products

^d Based on normal Pu-240 to Pu-239 value; RWMIS value is a factor of 10 lower.

^e mixed activation products

Table 2. Continued.

Shipment No.79-203
Vault location:C-7-2

Container No.N-52
Date:December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	6.986E-09	9.029E-13
fission product	Sr 90	6.772E-01	4.965E-03
fission product	Cs134	1.858E-04	1.436E-07
fission product	Cs137	6.886E-01	7.917E-03
fission product	Ce144	1.514E-09	4.747E-13
actinide	U235	6.660E-05	3.081E+01
actinide	U238	5.140E-06	1.529E+01
actinide	Pu239	7.915E-01	1.273E+01
actinide	Pu240	4.199E-01	1.843E+00
Total		2.577E+00	6.069E+01

Shipment No.80-52
Vault location:C-8-1

Container No.N-55
Date:December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Sr 90	3.402E+01	2.494E-01
fission product	Ru106	3.000E+00	8.967E-04
fission product	Cs134	1.324E-02	1.023E-05
fission product	Cs137	3.459E+01	3.977E-01
fission product	Ce144	2.406E-08	7.544E-12
actinide	U235	6.730E-05	3.114E+01
actinide	U238	6.460E-05	1.922E+02
actinide	Pu239	8.124E-02	1.307E+00
actinide	Pu240	1.596E-02	7.004E-02
	MFP ^f	1.000E+00	---
Total		7.271E+01	2.253E+02

Shipment No.80-81
Vault location:C-2-1

Container No.B-288
Date:December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Sr 90	3.417E+00	2.505E-02
fission product	Cs134	1.057E-03	8.169E-07
fission product	Cs137	3.474E+00	3.994E-02
fission product	Ce144	1.065E-08	3.339E-12
actinide	U235	4.020E-04	1.860E+02
actinide	U238	3.430E-05	1.020E+02
actinide	Pu239	6.566E-02	1.056E+00
actinide	Pu240	7.152E-03	3.139E-02
Total		6.965E+00	2.892E+02

^f mixed fission products

Table 2. Continued.

Shipment No. 80-145

Container No. B-287

Vault location: C-8-2

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	1.789E-08	2.311E-12
fission product	Cs137	1.165E+00	1.340E-02
actinide	U235	4.020E-04	1.860E+02
actinide	U238	1.740E-04	5.176E+02
actinide	Pu239	2.558E-01	4.116E+00
actinide	Pu240	9.776E-02	4.290E-01
	MAP ^g	1.000E+00	---
	MFP ^h	1.000E+00	---
Total		3.519E+00	7.082E+02

Shipment No. 80-158

Container No. N-68

Vault location: C-5-2

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	1.266E-08	1.636E-12
fission product	Cs137	1.167E+00	1.342E-02
fission product	Ce144	1.940E-09	6.083E-13
actinide	U235	3.600E-05	1.666E+01
actinide	U238	3.800E-06	1.130E+01
actinide	Pu239	1.599E-01	2.572E+00
actinide	Pu240	9.576E-02	4.203E-01
	MAP ^g	1.000E+00	---
	MFP ^h	1.000E+00	---
Total		3.423E+00	3.097E+01

Shipment No. 81-81

Container No. N-77

Vault location: B-2-2

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	7.234E-09	9.349E-13
activation product	Fe 59	1.000E-02	2.033E-07
activation product	Co 60	1.516E-03	1.340E-06
fission product	Sr 90	3.787E+01	2.776E-01
fission product	Cs134	1.943E-02	1.502E-05
fission product	Cs137	5.031E+01	5.784E-01
fission product	Ce144	1.164E-07	3.649E-11
actinide	U235	4.800E-05	2.221E+01
actinide	U238	4.100E-06	1.220E+01
actinide	Pu239	1.899E-02	3.055E-01
actinide	Pu240	7.183E-03	3.152E-02
Total		8.824E+01	3.560E+01

^g mixed activation products

^h mixed fission products

Table 2. Continued.

Shipment No.81-91
Vault location: C-2-2

Container No. N-79
Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	2.529E-07	3.269E-11
activation product	Fe 59	1.000E+00	2.033E-05
activation product	Co 60	5.103E-02	4.514E-05
fission product	Sr 90	6.129E+01	4.493E-01
fission product	Cs134	3.090E-02	2.389E-05
fission product	Cs137	8.716E+01	1.002E+00
fission product	Ce144	1.870E-07	5.861E-11
actinide	U235	6.700E-05	3.100E+01
actinide	U238	5.600E-06	1.666E+01
actinide	Pu239	8.395E-01	1.351E+01
actinide	Pu240	4.689E-01	2.058E+00
Total		1.508E+02	6.468E+01

Shipment No.81-122
Vault location: B-3-1

Container No. B-296
Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Cs137	2.379E+00	2.735E-02
fission product	Ce144	9.935E-09	3.115E-12
actinide	U235	4.100E-04	1.897E+02
actinide	U238	4.800E-05	1.428E+02
actinide	Pu239	9.594E-02	1.543E+00
actinide	Pu240	3.093E-02	1.357E-01
	MFP ⁱ	1.000E+00	---
Total		3.506E+00	3.342E+01

Shipment No.81-177
Vault location: C-6-2

Container No. N-85
Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	3.397E-08	4.390E-12
activation product	Co 60	2.738E-02	2.422E-05
fission product	Sr 90	6.267E+00	4.594E-02
fission product	Cs134	3.164E-03	2.445E-06
fission product	Cs137	6.364E+00	7.316E-02
fission product	Ce144	7.610E-08	2.386E-11
actinide	U235	2.300E-05	1.064E+01
actinide	U238	3.300E-06	9.816E+00
actinide	Pu239	2.798E-02	4.502E-01
actinide	Pu240	2.195E-02	9.633E-02
Total		1.271E+01	2.112E+01

ⁱ mixed fission products

Table 2. Continued.

Shipment No. 81-2

Container No. B-293

Vault location: B-2-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	2.365E-08	3.057E-12
fission product	Cs137	1.175E+00	1.350E-02
actinide	U235	4.210E-04	1.948E+02
actinide	U238	3.850E-05	1.145E+02
actinide	Pu239	5.601E-02 ^j	9.010E-01
actinide	Pu240	1.554E-02 ^d	6.819E-02
	MAP ^k	1.000E+00	---
	MFP ^l	1.000E+00	---
Total		3.247E+00	3.103E+02

Shipment No. 82-38

Container No. B-203

Vault location: B-3-2

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	6.753E-08	8.728E-12
fission product	Sr 90	1.073E+00	7.866E-03
fission product	Cs134	6.039E-04 ^m	4.667E-07
fission product	Cs137	1.089E+00	1.252E-02
fission product	Ce144	1.761E-08	5.521E-12
actinide	U235	3.450E-04	1.596E+02
actinide	U238	3.900E-05	1.160E+02
actinide	Pu239	1.199E-01	1.929E+00
actinide	Pu240	1.397E-02	6.130E-02
Total		2.297E+00	2.776E+02

Shipment No. 82-66

Container No. N-94

Vault location: C-4-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	5.294E-08	6.841E-12
activation product	Co 60	5.885E-02	5.205E-05
fission product	Sr 90	1.390E+01	1.019E-01
fission product	Cs134	8.324E-03	6.434E-06
fission product	Cs137	1.411E+01	1.622E-01
fission product	Ce144	2.712E-07	8.503E-11
actinide	U235	1.500E-05	6.940E+00
actinide	U238	1.600E-06	4.759E+00
actinide	Pu239	1.899E-01	3.055E+00
actinide	Pu240	1.297E-01	5.692E-01
Total		2.840E+01	1.559E+01

^j Based on total plutonium of 0.59 g from ANL-W can log and average Pu-240 to Pu-239 mass ratio (7.58%) of other shipments made in 1980.

^k mixed activation products

^l mixed fission products

^m RWMIS shows 9E-09 at time of shipment; changed to 9E-01 at time of shipment to be consistent with expected Cs134 to Cs137 ratio.

Table 2. Continued.

Shipment No. 82-118
Vault location: C-4-2

Container No. N-96
Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	5.521E-08	7.136E-12
fission product	Sr 90	7.196E-01	5.276E-03
fission product	Cs134	4.382E-04	3.387E-07
fission product	Cs137	7.305E-01	8.398E-03
fission product	Ce144	1.469E-08	4.607E-12
actinide	U235	3.600E-05	1.666E+01
actinide	U238	4.000E-05	1.190E+02
actinide	Pu239	8.695E-02	1.399E+00
actinide	Pu240	2.195E-02	9.633E-02
Total		1.560E+00	1.372E+02

Shipment No. 83-4
Vault location: C-3-1

Container No. N-105
Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	8.304E-08	1.073E-11
fission product	Sr 90	7.283E-01	5.340E-03
fission product	Cs134	5.190E-04	4.012E-07
fission product	Cs137	7.390E-01	8.496E-03
fission product	Ce144	2.302E-08	7.215E-12
actinide	U235	9.300E-05	4.303E+01
actinide	U238	8.600E-06	2.558E+01
actinide	Pu239	1.699E-02	2.733E-01
actinide	Pu240	4.789E-03 ⁿ	2.102E-02
Total		1.485E+00	6.890E+01

Shipment No. 83-20
Vault location: C-3-2

Container No. N-104
Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	8.895E-08	1.150E-11
fission product	Sr 90	7.298E-01	5.350E-03
fission product	Cs134	5.340E-04	4.128E-07
fission product	Cs137	7.405E-01	8.513E-03
fission product	Ce144	2.482E-08	7.782E-12
actinide	U235	1.700E-05	7.865E+00
actinide	U238	1.600E-06	4.759E+00
actinide	Pu239	3.298E-03	5.306E-02
actinide	Pu240	7.184E-04 ^o	3.153E-03
Total		1.474E+00	1.269E+01

ⁿ RWMIS shows 4.8E-4 at time of shipment.

^o RWMIS shows 7.2E-5 at time of shipment.

Table 2. Continued.

Shipment No.83-133

Container No.N-111

Vault location: B-4-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	1.859E-07	2.402E-11
activation product	Fe 59	3.300E-01	6.710E-06
activation product	Co 60	2.268E-02	2.006E-05
fission product	Sr 90	2.156E+01	1.581E-01
fission product	Cs134	1.867E-02	1.443E-05
fission product	Cs137	2.187E+01	2.514E-01
fission product	Ce144	1.170E-06	3.669E-10
actinide	U235	1.800E-05	8.328E+00
actinide	U238	1.800E-05	5.354E+01
actinide	Pu239	3.498E-02	5.628E-01
actinide	Pu240	3.093E-03	1.358E-02
Total		4.384E+01	6.285E+01

Shipment No.84-008

Container No.O-31

Vault location: B-5-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	2.560E-06	3.308E-10
activation product	Fe 59	2.000E+00	4.067E-05
activation product	Co 60	5.725E-01	5.064E-04
actinide	U235	4.620E-05	2.137E+01
actinide	U238	2.780E-06	8.269E+00
actinide	Pu239	4.857E-01	7.814E+00
actinide	Pu240	2.555E-01	1.121E+00
Total		3.314E+00	3.857E+01

Shipment No.85-013

Container No.85-013

Vault location: D-1-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	3.482E-06	4.501E-10
activation product	Fe 59	1.000E+00	2.033E-05
activation product	Co 60	9.210E-01	8.146E-04
fission product	Sr 90	2.841E+02	2.083E+00
fission product	Cs134	3.940E-01	3.045E-04
fission product	Cs137	2.878E+02	3.309E+00
fission product	Ce144	5.649E-05	1.771E-08
actinide	U235	3.210E-04	1.485E+02
actinide	U238	5.000E-05	1.487E+02
actinide	Pu239	1.269E-01	2.042E+00
actinide	Pu240	5.010E-02	2.199E-01
Total		5.744E+02	3.049E+02

Table 2. Continued.

Shipment No.87-023

Container No.87-098

Vault location: B-6-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	2.568E-06	3.318E-10
fission product	Sr 90	8.351E+01	6.122E-01
fission product	Cs134	2.234E-01	1.727E-04
fission product	Cs137	8.449E+01	9.713E-01
fission product	Ce144	1.037E-04	3.252E-08
actinide	U235	8.641E-05	3.998E+01
actinide	U238	1.811E-05	5.387E+01
actinide	Pu239	1.252E-01	2.015E+00
actinide	Pu240	3.436E-02	1.508E-01
Total		1.684E+02	9.760E+01

Shipment No.87-029

Container No.87-105

Vault location: B-7-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	2.672E-06	3.453E-10
fission product	Sr 90	6.183E+01	4.533E-01
fission product	Cs134	1.680E-01	1.299E-04
fission product	Cs137	6.255E+01	7.192E-01
fission product	Ce144	8.016E-05	2.513E-08
actinide	U235	1.496E-04	6.921E+01
actinide	U238	1.860E-05	5.533E+01
actinide	Pu239	4.492E-01	7.227E+00
actinide	Pu240	1.145E-01	5.025E-01
Total		1.251E+02	1.334E+02

Shipment No.87-038

Container No.87-107

Vault location: B-8-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	2.985E-06	3.858E-10
fission product	Sr 90	2.899E+01	2.126E-01
fission product	Cs134	8.414E-02	6.503E-05
fission product	Cs137	2.933E+01	3.372E-01
fission product	Ce144	4.252E-05	1.333E-08
actinide	U235	4.843E-05	2.241E+01
actinide	U238	9.277E-06	2.760E+01
actinide	Pu239	2.252E-01	3.623E+00
actinide	Pu240	5.798E-02	2.545E-01
Total		5.869E+01	5.444E+01

Table 2. Continued.

Shipment No.87-049

Container No.87-114

Vault location:E-1-1

Date:December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	3.395E-06	4.388E-10
fission product	Sr 90	6.185E+00	4.534E-02
fission product	Cs134	1.843E-02	1.424E-05
fission product	Cs137	6.256E+00	7.192E-02
fission product	Ce144	1.036E-05	3.247E-09
actinide	U235	1.445E-05	6.685E+00
actinide	U238	7.213E-06	2.146E+01
actinide	Pu239	2.685E-01	4.319E+00
actinide	Pu240	6.155E-02	2.701E-01
Total		1.279E+01	3.285E+01

Shipment No.87-070

Container No.87-203

Vault location:D-2

Date:December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	4.286E-06	5.539E-10
fission product	Sr 90	8.587E+00	6.295E-02
fission product	Cs134	2.799E-02	2.164E-05
fission product	Cs137	8.683E+00	9.983E-02
fission product	Ce144	1.845E-05	5.785E-09
actinide	U235	2.363E-05	1.093E+01
actinide	U238	1.024E-05	3.046E+01
actinide	Pu239	4.776E-01	7.683E+00
actinide	Pu240	3.946E-01	1.732E+00
Total		1.817E+01	5.097E+01

Shipment No.88-016

Container No.88-090

Vault location:B-6-2

Date:December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	5.458E-06	7.054E-10
activation product	Co 60	1.249E-01	1.105E-04
fission product	Sr 90	8.854E+01	6.491E-01
fission product	Cs134	3.193E-01	2.468E-04
fission product	Cs137	8.952E+01	1.029E+00
fission product	Ce144	2.468E-04	7.738E-08
actinide	U235	1.758E-04	8.133E+01
actinide	U238	5.255E-05	1.563E+02
actinide	Pu239	1.893E+00	3.046E+01
actinide	Pu240	4.676E-01	2.052E+00
Total		1.809E+02	2.718E+02

Table 2. Continued.

Shipment No.88-031

Container No.88-130

Vault location: E-2-2

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Mn 54	6.018E-06	7.777E-10
fission product	Sr 90	3.583E+02	2.627E+00
fission product	Cs134	1.332E+00	1.029E-03
fission product	Cs137	3.622E+02	4.164E+00
fission product	Ce144	1.107E-03	3.470E-07
actinide	Th232	5.995E-05	5.466E+02
actinide	U233	9.611E-02	9.929E+00
actinide	U235	2.819E-04	1.304E+02
actinide	U238	2.893E-04	8.606E+02
actinide	Np237	3.454E-05	4.900E-02
actinide	Pu239	1.992E+00	3.205E+01
actinide	Pu240	6.847E-01	3.005E+00
Total		7.246E+02	1.589E+03

Table 2. Continued.

Shipment No.88-025

Container No.88-107

Vault location: E-2-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Fe 55	4.906E-02	1.963E-05
activation product	Co 60	1.796E+00	1.589E-03
activation product	Ni 63	2.708E+00	4.390E-02
fission product	Kr 85	2.106E+00	5.367E-03
fission product	Sr 90	4.540E+01	3.329E-01
fission product	Y 90	4.541E+01	8.347E-05
fission product	Ru106	2.640E-05	7.889E-09
fission product	Rh106	2.640E-05	7.416E-15
fission product	Sb125	8.175E-02	7.918E-05
fission product	Cs134	1.236E-01	9.550E-05
fission product	Cs137	4.613E+01	5.303E-01
fission product	Ba137M	4.355E+01	8.096E-08
fission product	Ce144	1.102E-05	3.456E-09
fission product	Pr144	1.102E-05	1.459E-13
fission product	Pm147	9.036E-01	9.748E-04
actinide	Th232	5.957E-06	5.432E+01
actinide	U233	5.579E-02	5.763E+00
actinide	U235	5.935E-05	2.746E+01
actinide	Np237	5.428E-04	7.701E-01
actinide	Np239	5.121E-04	2.208E-09
actinide	Pu238	4.987E+00	2.913E-01
actinide	Pu239	4.592E-03	7.388E-02
actinide	Pu240	4.628E-03	2.031E-02
actinide	Pu242	4.462E-05	1.169E-02
actinide	Am241	4.105E-03	1.196E-03
actinide	Am242	2.124E-04	2.628E-10
actinide	Am242M	2.124E-04	2.186E-05
actinide	Am243	5.121E-04	2.569E-03
actinide	Cm242	2.131E-04	6.444E-08
actinide	Cm243	8.721E-03	1.690E-04
Total		1.933E+02	8.963E+01

Table 2. Continued.

Shipment No.88-045

Container No.88-164

Vault location: E-3-1

Date: December 31, 2003

Category	Isotope	Activity (Ci)	Mass (g)
activation product	Fe 55	9.760E-03	3.904E-06
activation product	Co 60	3.339E-01	2.953E-04
activation product	Ni 63	5.744E-01	9.313E-03
fission product	Kr 85	1.295E+00	3.300E-03
fission product	Sr 90	2.468E+01	1.809E-01
fission product	Y 90	2.468E+01	4.537E-05
fission product	Sb125	2.306E-02	2.233E-05
fission product	Cs134	5.620E-02	4.344E-05
fission product	Cs137	2.511E+01	2.887E-01
fission product	Ba137M	2.370E+01	4.407E-08
fission product	Ce144	2.308E-06	7.236E-10
fission product	Pr144	2.308E-06	3.056E-14
fission product	Pm147	4.353E-01	4.696E-04
actinide	Th232	8.821E-06	8.043E+01
actinide	U233	8.638E-02	8.924E+00
actinide	U235	2.025E-05	9.369E+00
actinide	Np237	1.833E-04	2.601E-01
actinide	Np239	1.776E-04	7.658E-10
actinide	Pu238	1.732E+00	1.012E-01
actinide	Pu239	1.593E-03	2.563E-02
actinide	Pu240	1.605E-03	7.046E-03
actinide	Pu242	1.548E-05	4.054E-03
actinide	Am241	1.424E-03	4.149E-04
actinide	Am242	7.372E-05	9.120E-11
actinide	Am242M	7.372E-05	7.586E-06
actinide	Am243	1.776E-04	8.912E-04
actinide	Cm242	7.394E-05	2.236E-08
actinide	Cm243	3.035E-03	5.880E-05
	Total	1.027E+02	9.961E+01

5. Projected Dose Rates of Inserts

Of particular interest to retrieval operations is the surface dose rates of the inserts, which determine the level of safety precautions needed to minimize dose to workers. Most, but not all, of the inserts have documented dose rates at time of packaging (ANL-W can log), or shipment (RWMIS). The available dose rates at time of shipment and the respective Co-60 and Cs-137 contents of the inserts are given in Table 3.

Table 3. Container radionuclide and dose rate information at time of shipment.

Container No.	Co-60 activity (Ci)	Cs-137 activity (Ci)	Gamma Equivalent G	Dose rate (rem/hr)
N-55		60.00	33.76	504
B-287		2.00	1.13	5
N-68		2.00	1.13	255
N-77	0.03	85.00	47.90	648
N-79	1.00	147.00	85.22	1264
N-85	0.50	10.60	7.22	141
N-94	1.00	23.20	15.56	299
N-111	0.33	35.00	20.52	447
O-31	8.00		20.04	119
87-098		124.40	70.00	657
87-105		92.00	51.77	489
87-107		43.00	24.20	231
87-114		9.14	5.14	52
87-203		12.60	7.09	70
88-090	1.00	129.00	75.09	693
88-064		0.17	0.10	5
88-065		0.24	0.14	4
88-130		520.50	292.89	2737
88-068		0.13	0.07	2
88-134		0.16	0.09	10
88-107	14.19	66.32	72.86	241
88-164	2.59	35.99	26.75	50

These dose rates are correlated to what we call here the "gamma equivalent, G," which is defined as

$$G = (1.173 + 1.332) \times (^{60}\text{Co activity in Ci}) + 0.662 \times 0.85 \times (^{137}\text{Cs activity in Ci}) .$$

The numerical factors in the above equation is the energy (energies) of the gamma rays in MeV multiplied by the yield (number of gamma rays at that energy) per decay. ^{60}Co has two gamma rays at 1.173 and 1.332 MeV, both at 100% yield, and ^{137}Cs has one gamma ray at 0.662 MeV at 85% yield.

A linear regression on the dose rate as a function of the gamma equivalent for all inserts and also the four 55-gal drums (see Section 6) from ANL-W yields

$$\text{Dose rate (rem/hr)} = 45.3 + 9.23 \times G .$$

The intercept has a standard error of 45.4 (t-value of 1.00; intercept not significantly different from zero) and the slope has a standard error of 0.622 (t-value of 14.9; very highly significant correlation). The scatter diagram with the regression line is shown in Figure 3.

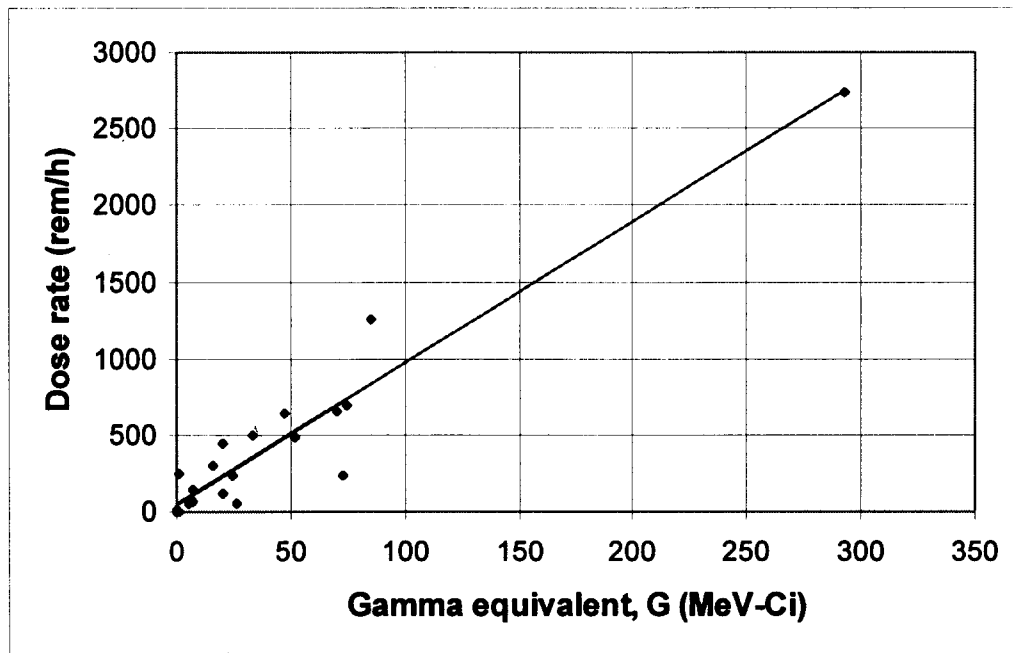


Figure 3. Dose rate as function of gamma equivalent.

Based on the regression line, the anticipated contact dose rates of the inserts as of December 31, 2003 are shown in Table 3. Also shown in the table are the 95% confidence interval upper and lower bounds of the dose rates. If the 95% lower bound dose rate falls below zero based on the standard error estimates, it is set to zero.

Table 4. Anticipated contact dose rates of ANL-W inserts as of December 31, 2003.

Shipment No.	Container No.	Anticipated dose rate (rem/hr)	95% upper bound dose rate (rem/hr)	95% lower bound dose rate (rem/hr)
78-204	B-254	51	439	0
79-57	B-262	46	435	0
79-74	B-266	51	439	0
79-203	N-52	49	437	0
80-52	N-55	225	611	0
80-81	B-288	63	451	0
80-145	B-287	51	440	0
80-158	N-68	51	440	0
81-2	B-293	51	440	0
81-81	N-77	307	692	0
81-91	N-79	499	884	114
81-122	B-296	58	446	0
81-177	N-85	79	467	0
82-38	B-203	51	439	0
82-66	N-94	120	507	0
82-118	N-96	49	437	0
83-4	N-105	49	437	0
83-20	N-104	49	437	0
83-133	N-111	159	546	0
84-008	O-31	59	447	0
85-013	85-013	1,562	1,979	1,144
87-023	87-098	484	869	99
87-029	87-105	370	755	0
87-038	87-107	198	584	0
87-049	87-114	78	466	0
87-070	87-203	90	478	0
88-016	88-090	513	898	128
88-031	88-130	1,927	2,367	1,486
88-025	88-107	326	712	0
88-045	88-164	183	570	0

6. Information on Four Additional 55-gal Drums from ANL-W

In 1988, four 55-gal drums were shipped to the RWMC from ANL-W from building ANL752. These have similar radioisotope contents as the inserts and are also expected to be shipped back to ANL-W for processing before disposal at the WIPP. Information for these drums are shown in Table 4.

Table 5. Information on four 55-gal drums from ANL-W.

Shipment No.88-018 Container No.88-064
Origin:ANL752 Shipment date:March 28, 1988
Mass (kg):62.2
Vault location:F-10-1 Date:December 31, 2003
Expected dose rate (rem/hr):45.9
95% bounds (rem/hr):(434, 0)

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Nb 95	1.740E-01	4.450E-06
fission product	Zr 95	1.050E-01	4.888E-06
fission product	Cs137	1.181E-01	1.358E-03
fission product	Ce144	4.060E-07	1.273E-10
actinide	U235	2.800E-07	1.295E-01
actinide	U238	4.000E-08	1.190E-01
actinide	Pu239	9.496E-01	1.528E+01
actinide	Pu240	1.846E-02	8.101E-02
Total		1.365E+00	1.561E+01

Shipment No.88-018 Container No.88-065
Origin:ANL752 Shipment date:March 28, 1988
Mass (kg):63.6
Vault location:F-10-2 Date:December 31, 2003
Expected dose rate (rem/hr):46.2
95% bounds (rem/hr):(435, 0)

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Nb 95	2.460E-01	6.291E-06
fission product	Zr 95	1.470E-01	6.843E-06
fission product	Cs137	1.668E-01	1.917E-03
fission product	Ce144	5.729E-07	1.796E-10
actinide	U235	3.900E-07	1.804E-01
actinide	U238	5.000E-08	1.487E-01
actinide	Pu239	1.349E+00	2.171E+01
actinide	Pu240	2.623E-02	1.151E-01
Total		1.935E+00	2.216E+01

Table 4. Continued.

Shipment No.88-033 Container No.88-068
Origin:ANL752 Shipment date:May 26, 1988
Mass (kg):78.1
Vault location:C-44-2 Date:December 31, 2003
Expected dose rate (rem/hr):45.8
95% bounds (rem/hr):(434, 0)

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Nb 95	1.300E-01	3.325E-06
fission product	Zr 95	8.000E-02	3.724E-06
fission product	Cs137	9.066E-02	1.042E-03
fission product	Ce144	3.521E-07	1.104E-10
actinide	U235	3.400E-07	1.573E-01
actinide	U238	1.000E-08	2.975E-02
actinide	Pu239	4.298E-03	6.915E-02
actinide	Pu240	2.206E-03	9.683E-03
Total		3.072E-01	2.669E-01

Shipment No.88-033 Container No.88-134
Origin:ANL752 Shipment date:May 26, 1988
Mass (kg):61.3
Vault location:C-44-1 Date:December 31, 2003
Expected dose rate (rem/hr):45.9
95% bounds (rem/hr):(434, 0)

Category	Isotope	Activity (Ci)	Mass (g)
fission product	Nb 95	1.700E-01	4.348E-06
fission product	Zr 95	1.000E-01	4.655E-06
fission product	Cs137	1.116E-01	1.283E-03
fission product	Ce144	4.540E-07	1.423E-10
actinide	U235	3.400E-07	1.573E-01
actinide	U238	1.000E-08	2.975E-02
actinide	Pu239	4.298E-03	6.915E-02
actinide	Pu240	2.196E-03	9.639E-03
Total		3.881E-01	2.671E-01

7. Discussion and Conclusion

Aside from suspected typographical errors and one insert (shipment number 88-070, container number 87-203), whose storage location is uncertain, storage locations for all inserts and the four 55-gal drums from ANL-W are found in the RWMIS database and verified with the ILTSF vault log. The consistency among different sources of information gives confidence that the inserts can be unmistakably located and retrieved.

The radionuclide contents information in the RWMIS database may have a few typographical errors, as seen from a simple test of expected isotope ratios. However, the errors all related to minor radionuclides, most of which would have decayed by the retrieval time so that even without correcting them, they would not have much impact on any future radionuclide characterization for the inserts. The listing of radionuclides is not entirely consistent in the RWMIS database. For example, the two inserts from Bettis have the most complete listing of expected radionuclides, while the inserts from ANL-W do not list the short-lived radionuclides, which are in secular equilibrium with their parent radionuclides (e.g., Y-90 and Ba-137M). In addition, Sr-90 contents are not listed in many of the inserts, although they certainly are present based on the presence of Cs-137, whose contents are listed. The omission of these radionuclides reduces the total activity attributed to the waste.

The expected dose rates of the inserts in this EDF are derived from a correlation between dose rates and gamma equivalents developed from data collected at the time of shipment or packaging. Because the original dose rate data span a large range, from a few rem/hr to over 1000 rem/hr, the standard error of the regression is large (approximately 180 rem/hr). Consequently, for expected dose rates less than 200 to 300 rem/hr, the percentage errors in the expected dose rates are large and are likely to be over-estimates.

Based on the expected contact dose rates of many of the ANL-W inserts exceeding 100 rem/hr, shielding and/or remote handling are necessary to minimize exposure to retrieval workers. Any exposure time to unshielded inserts must also be minimized.

8. References

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3. Intermediate Level Transuranic Storage Facility (ILTSF) storage log, RH-TRU program files.
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